PROC. BIOL. SOC. WASH.
107(4), 1994, pp. 707–720

TWO NEW SPECIES OF *PODOCERUS* LEACH (CRUSTACEA: AMPHIPODA: PODOCERIDAE) FROM BERMUDA

Adam J. Baldinger and Michael F. Gable

Abstract.—Two new species, *Podocerus tachyrheo* and *Podocerus lazowasemi,* are described from Bermuda. *Podocerus tachyrheo* is a non-carinate, highly pigmented species lacking uropodal interramal spines; *P. lazowasemi* possesses distinct uropodal interramal spines and dorsal carinations, but usually lacks pigmentation.

In Kunkel's (1910) monograph on the amphipods of Bermuda no specimens of the genus *Podocerus* were recorded. Johnson (1986) and Gable et al. (1988), however, both refer to the existence of a single species of *Podocerus* in Bermuda. Examination of collections at the Yale Peabody Museum (YPM) and at the National Museum of Natural History (USNM) clearly documents the presence of two species of *Podocerus* in Bermuda, both of which are newly described in this paper.

In the figures, body parts are marked by abbreviations as follows: A, antenna; Gn, gnathopod; LL, lower lip; Md, mandible; Mx, maxilla; Mxpd, maxilliped; P, pereopod; T, telson; U, uropod; UR, urosome.

Podocerus tachyrheo, new species
Figs. 1–5

Podocerus sp.—Johnson, 1986:378, fig. 125.—Gable et al., 1988:148–149.

Etymology.—Named for the ability of individuals of this species to live in areas of extremely swift (G. tachy-) currents (G. rheo), such as those at The Flatts, Bermuda, where all tidal flow from Harrington Sound moves through one narrow channel.

Diagnosis.—Pereon without dorsal carinations. Pereon segments 5–7 with dorsal and lateral spine groups, pleon segments 1–2 with dorsal spine groups only. Adult males and females with varying degrees of pigmentation. Coxal plates 1–5 with a strong distal spine. Male antennae 1–2, gnathopods 1–2, maxillae 1–2, mandibular palp, and maxilliped with plumose setae. Male antenna 2, flagellum 3-articulate and ornamented with submarginal spines. Female antennae 1–2, gnathopod 1, maxillae 1–2, mandibular palp, and maxilliped with plumose setae. Male gnathopod 2, article 5 masked by articles 4 and 6, palm with irregular margin bearing a proximal conical tooth and a distal rectangular process. Article 6 of all pereopods with strong bifurcate spines. Uropods 1–2 with bifurcate spines but lacking peduncular interramal spines.

Description.—Male: Body and appendages with pigmentation, body lacking dorsal carinae, pereon segments 5–7 and pleon segments 1–2 with dorsal distoposterior spine groups, pereon segments 5–7 also with lateral distoposterior spine groups. Coxae reduced with serial discontiguity, coxae 1–5 each with a large marginal spine, located anteriorly on coxae 1–4. Head less than pereonites 1 and 2 in length, cuboidal with ocular bulges. Eyes pigmented.

Antenna 1, 33% of total body length, peduncular ratio 1:3:2.7, flagellum 5-articulate; accessory flagellum 1-articulate and prominent. Antenna 2 greater than antenna 1 in

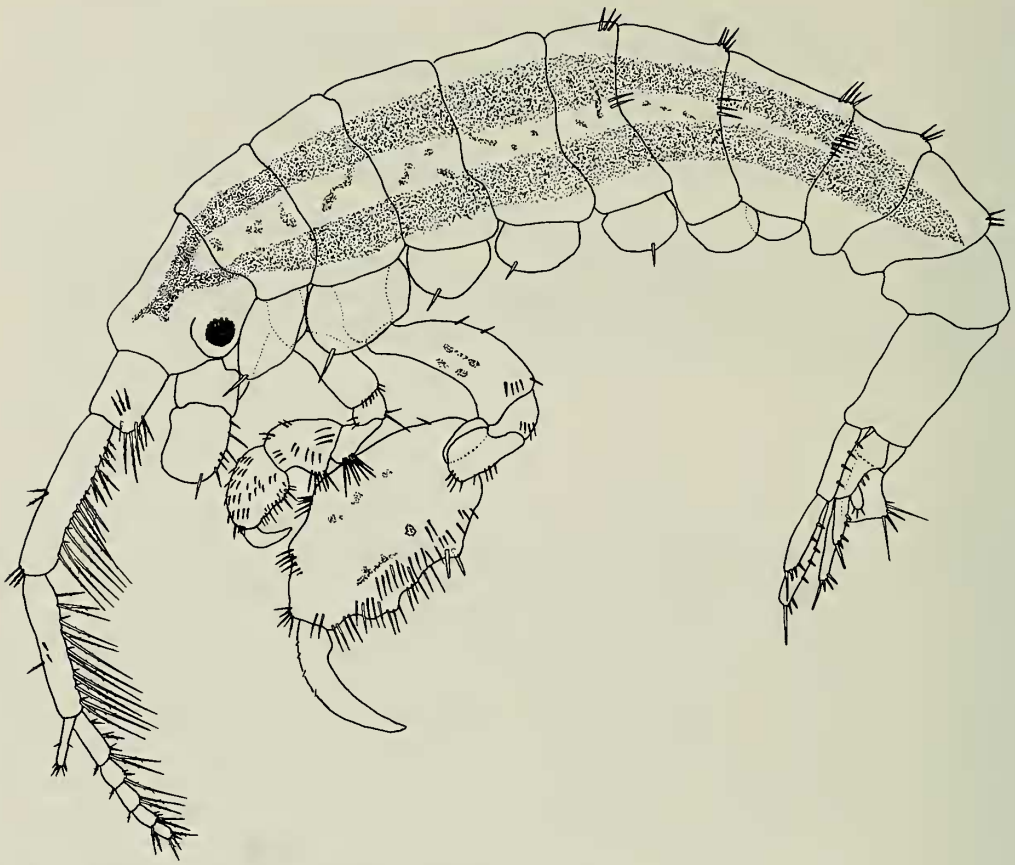

Fig. 1. *Podocerus tachyrheo,* male, 4.0 mm, YPM No. 9239.

length, articles 4 and 5 subequal, flagellum 3-articulate with distinct submarginal spines.

Mandible with 3-segmented palp, penultimate article triangular with marginal setae, terminal article clavate with facial and apical setae; incisor and lacinia both with 4 teeth; spine row of 3 short, broad spines; molar normal. Maxilla 1, inner plate vestigial; outer plate with 9 strong apical spines; palp 2-articulate, terminal article with 3 apical, medially bulging spines and 1 apical seta, 4 submarginal setae, and 4 facial spines. Maxilla 2, outer plate with 10 long apical setae; inner plate with 10 apical setae, inner margin with fine setae distally. Maxilliped, inner plate with marginal and submarginal setae and a single outer marginal spine; outer plate reaching 50% length of palp, with an inner marginal spine row and submarginal setae; palp 4-articulate, terminal article triangular. Lower lip, normal.

Gnathopod 1, coxal plate rhomboidal with a distinct distoanterior spine; article 6, palmar margin longer than hind margin; dactyl with 3 marginal setae. Gnathopod 2 heavily pigmented, robust, and much larger than gnathopod 1; article 5 hidden behind articles 4 and 6; palm of article 6 with irregular margin, bearing a proximal conical tooth and a distal rectangular process, margin heavily setose with 2 proximal spines. Bases of pereopods 3–7 with posterior plate-like extensions; article 6 of all pereopods with distally bifurcate spines.

Uropods 1 and 2 elongate, biramous,

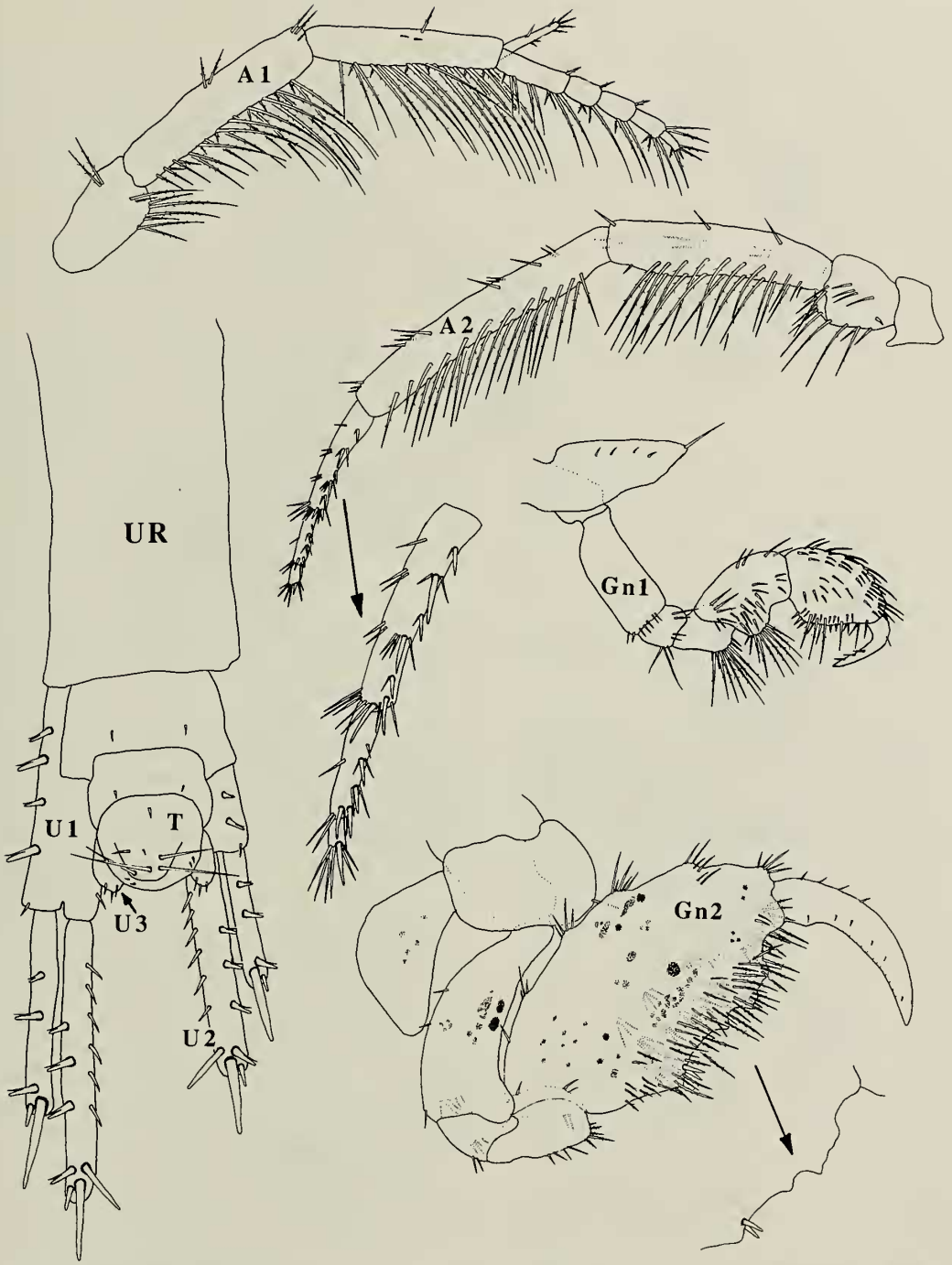

Fig. 2. *Podocerus tachyrheo,* male, 4.0 mm, YPM No. 9239: A1, Gn1, Gn2, UR (with left U1, right U2, right and left U3, T). Male, 2.9 mm, YPM No. 9242: A2.

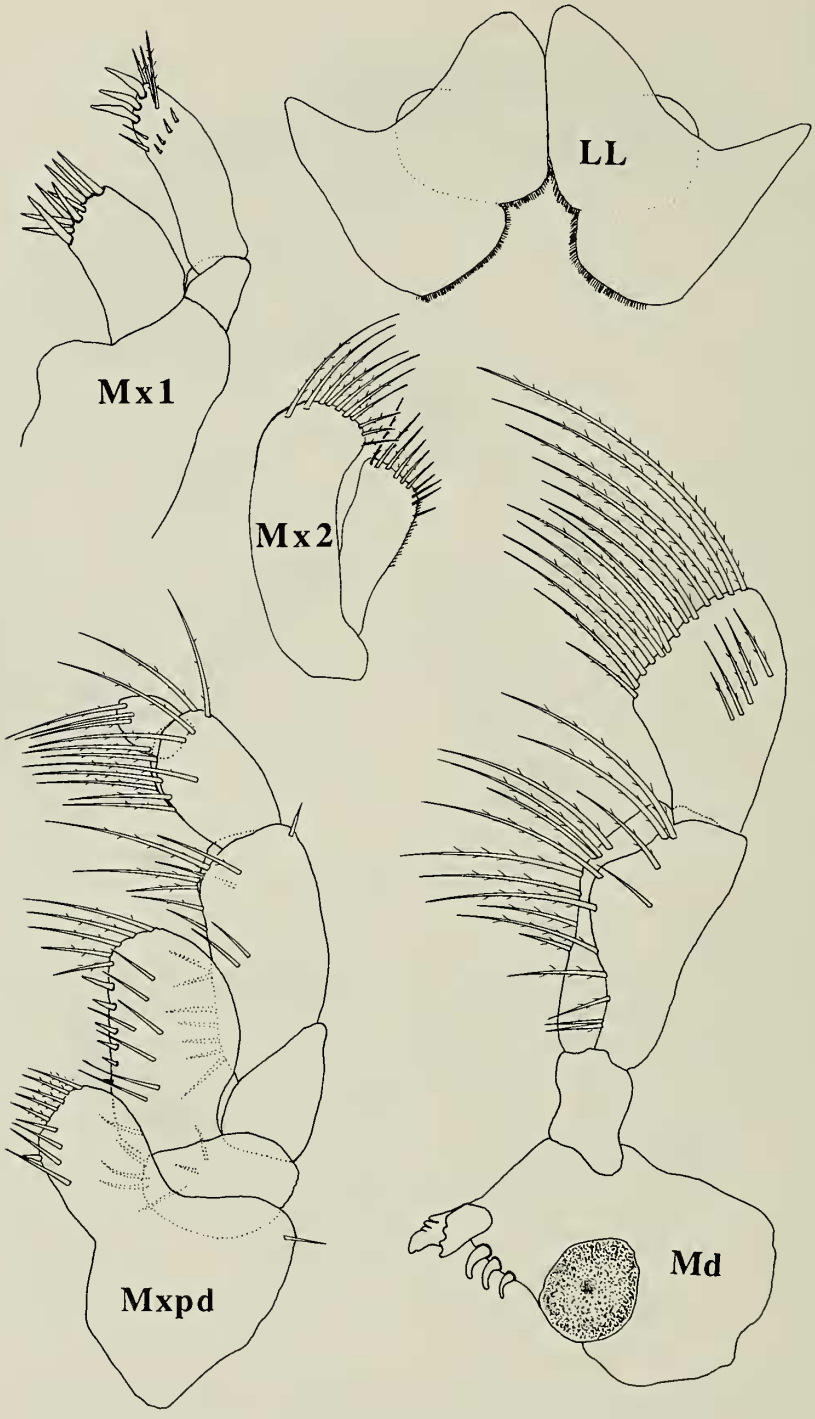

Fig. 3. *Podocerus tachyrheo*, male, 4.1 mm, YPM No. 9241.

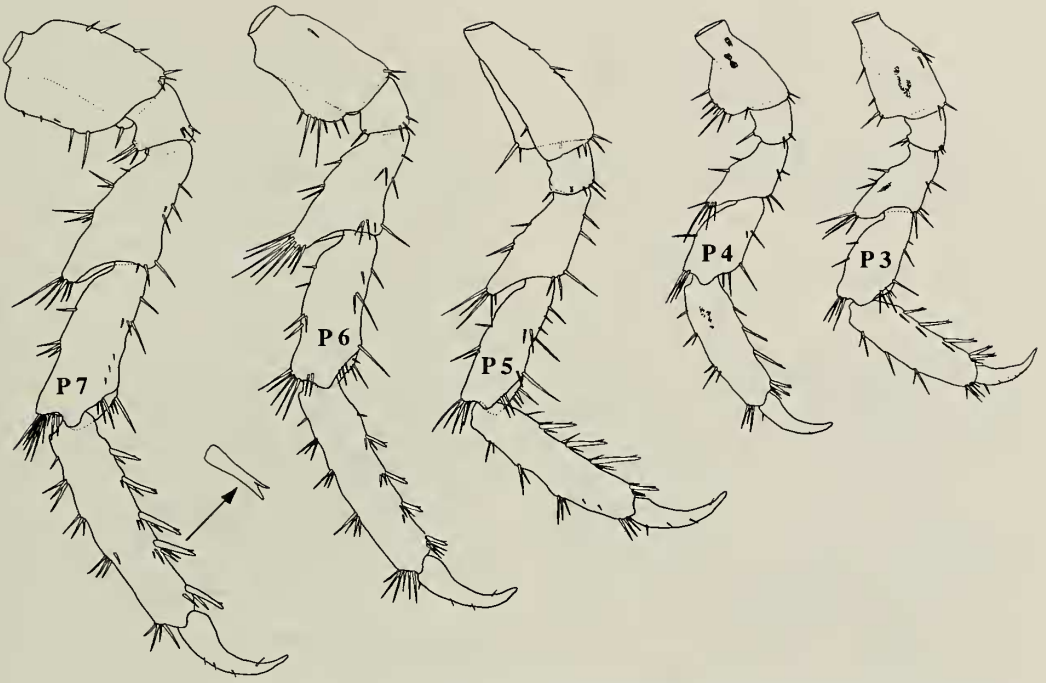

Fig. 4. *Podocerus tachyrheo,* male, 2.9 mm, YPM No. 9242: P3–P4. Male, 4.0 mm, YPM No. 9239: P5–7.

lacking interramal spines; peduncles and rami with marginal bifurcate spines, rami with distinct apical spines. Uropod 3 leaf-like with 3 apical setules. Telson dorsally produced and armed with 4 long setae and 6 short setules.

Female: All features same as those for male except as noted. Body lacking dorsal spine groups. Antenna 1, 40% of total body length; flagellum 4-articulate. Flagellum of antenna 2 lacking distinct submarginal spines. Gnathopod 1, article 6, proximal corner of palm demarcated by a spine. Gnathopod 2 resembling gnathopod 1 but twice the size and less ornamented.

Remarks.—The degree and patterns of pigmentation are variable among individuals of *P. tachyrheo*; juveniles, smaller males, and females may completely lack pigment. Larger males appear to have a uniform pigment band along the musculature of the pereon segments. Pigment has also been observed in males on almost every body segment, even on the most distal antennal segment. In females, however, pigmentation appears to become much denser on the ventral margin of the pereon, and may extend to the basal portions of the oostegites. Male/female differences in body spination, in the flagella of both antennae, in both gnathopods, and in pigmentation obviously make *P. tachyrheo* sexually dimorphic.

Podocerus tachyrheo is morphologically most closely related to *Podocerus multispinis* K. H. Barnard, 1925 and *Podocerus multispinis* var. *levis* K. H. Barnard, 1925. The only major difference between *P. multispinis* and *P. multispinis* var. *levis* is the almost complete absence of the dorsal spiniform tubercles in the variety (Barnard 1925). Based upon the description and one illustration of gnathopod 2 by both Barnard (1925) and Griffiths (1976), the most significant differences between *P. tachyrheo* and *P. multispinis* are: the number of flagellar

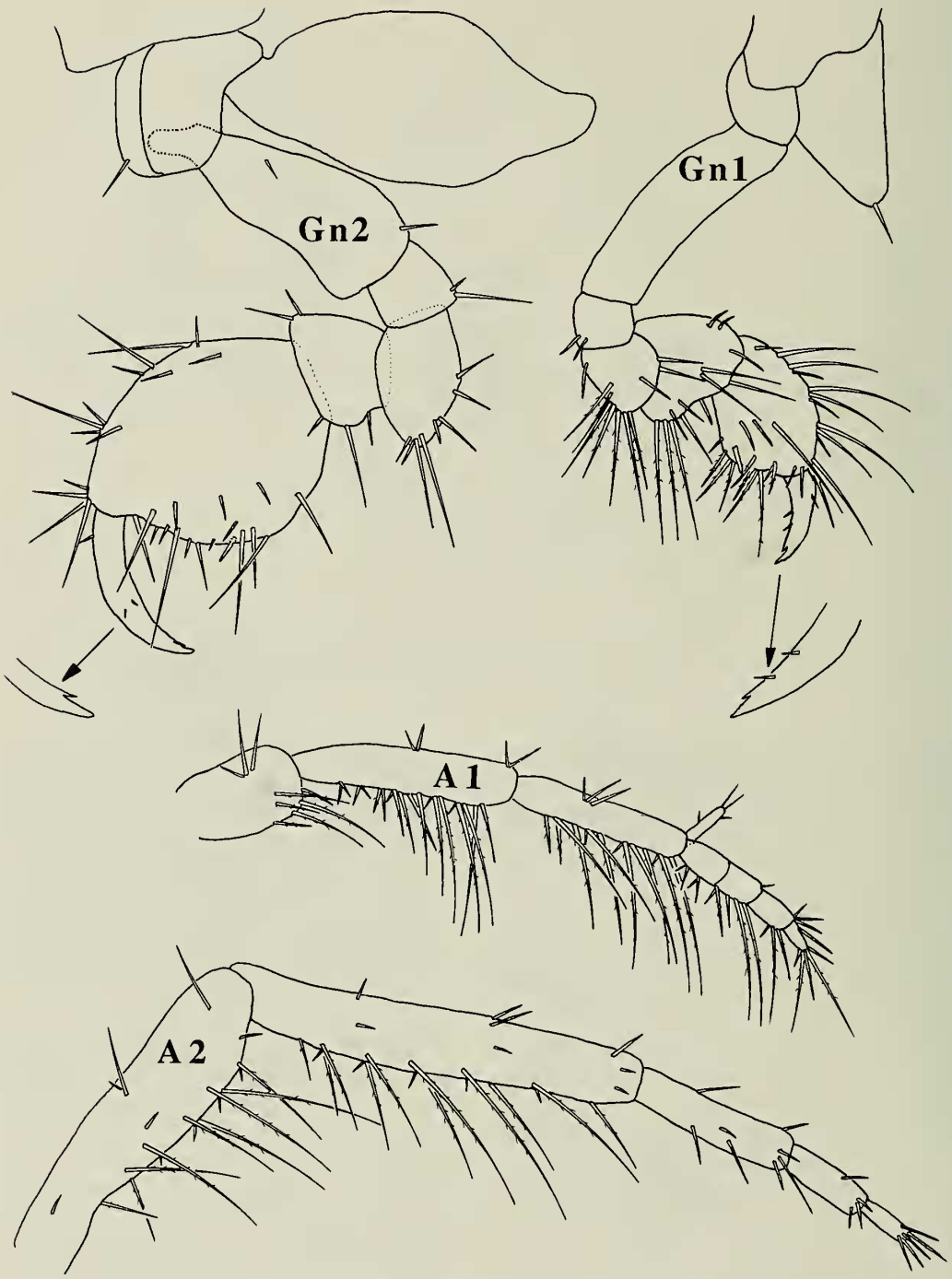

Fig. 5. *Podocerus tachyrheo,* female, 3.0 mm, YPM No. 9240.

articles of antenna 1, *P. tachyrheo* with five and *P. multispinis* with eight; the lateral spines on the pereon, present in *P. tachyrheo* and absent in *P. multispinis*; the number of setae present on the telson, four on *P. tachyrheo* and two on *P. multispinis*; the irregular margin of the palm of article 6 of gnathopod 2, *P. tachyrheo* with one tooth and one rectangular process and *P. multispinis,* as described by Barnard (1925), with two teeth and one rectangular process. In addition, Barnard (1925) does not mention *P. multispinis* or the variety as having pigmentation. Finally, although close morphologically to *P. tachyrheo, P. multispinis* is endemic from Natal to Saldanha Bay, South Africa (Griffiths 1975). *Podocerus tachyrheo,* therefore, may be considered a species endemic to Bermuda.

Other than its morphology, little is known about *P. tachyrheo.* In Bermuda most specimens collected were associated with hydroids; one collection yielded several hundred specimens taken from a small portion of a large colonial hydroid, *Halocordyle disticha* (Goldfuss), found attached in an area of very strong current.

Material examined.—Male holotype, YPM 9254, The Flatts, Harrington Sound, Bermuda, M. F. Gable, 23 May 1989, 5.0 mm, on *Halocordyle disticha* (Goldfuss) attached to a subtidal pipe. Female allotype, YPM 9245, The Flatts, Harrington Sound, Bermuda, M. F. Gable, 23 May 1989, 2.9 mm, mature, on *Halocordyle disticha* (Goldfuss) attached to a subtidal pipe. 1 male paratype, YPM 9239, Harrington Sound, behind Bermuda Aquarium, Bermuda, M. F. Gable, 2 Jun 1987, 4.0 mm, within hydroids and algae. 1 female paratype, YPM 9240, (same data as YPM 9239), 3.0 mm. 20 paratypes, males, females and juveniles, YPM 9243, Long Bird Causeway, Bermuda, S side and under causeway, E. A. Lazo-Wasem, 20 Jun 1988, washing of rocks. 1 male paratype, YPM 9241, The Flatts, Bermuda, M. F. Gable, 23 May 1989, 4.1 mm. 1 male paratype, YPM 9242 (same data as YPM 9241), 2.9 mm. 1 female paratype, ovigerous, YPM 9244 (same data as YPM 9243), 3.5 mm, highly pigmented. 5 paratypes, 2 males, 2 females, ovigerous, and 1 juvenile, deposited by YPM in Bermuda Museum of Natural History (same data as YPM 9243).

Podocerus lazowasemi, new species
Figs. 6–9

Etymology.—Named in appreciation for the technical assistance, sound advice, and encouragement received for this and many other projects from our colleague and good friend, E. A. Lazo-Wasem (YPM).

Diagnosis.—Pereon segments 6–7 and pleon segments 1–2 with dorsal carinations and spine groups. Coxal plates 1–7 each with 1 large marginal spine. Antennae 1–2, maxillae 1–2, maxilliped, and male gnathopods 1–2 with plumose setae. Maxilla 1, outer plate with 8 apical spines. Male gnathopod 1, article 6 with anterior marginal setae; gnathopod 2, palm at dactyl hinge with a pronounced rectangular process. Dactyls of all pereopods with a proximoanterior plumose seta. Peduncle of uropods 1–2 with interramal spine. Dorsal lobe of telson with 2 long and 2 short setae.

Description.—Male: Body unpigmented with conspicuous dorsal carinae and dorsal spine groups on pereon segments 6–7 and pleon segments 1–2. Coxae reduced with serial discontiguity, each with a large marginal spine. Head equal to pereonites 1–2 in length, cuboidal with lateral ocular bulges. Eyes pigmented.

Antenna 1, 40% of total body length, geniculate, article 2 slightly longer than article 3, flagellum 5-articulate; accessory flagellum, 1-articulate and prominent. Antenna 2, bigeniculate, article 5 nearly twice as long as article 4, flagellum 4-articulate and ornamented with spines and setal groups.

Mandible with 3-segmented palp, penultimate segment with submarginal and marginal setae, terminal article clavate with

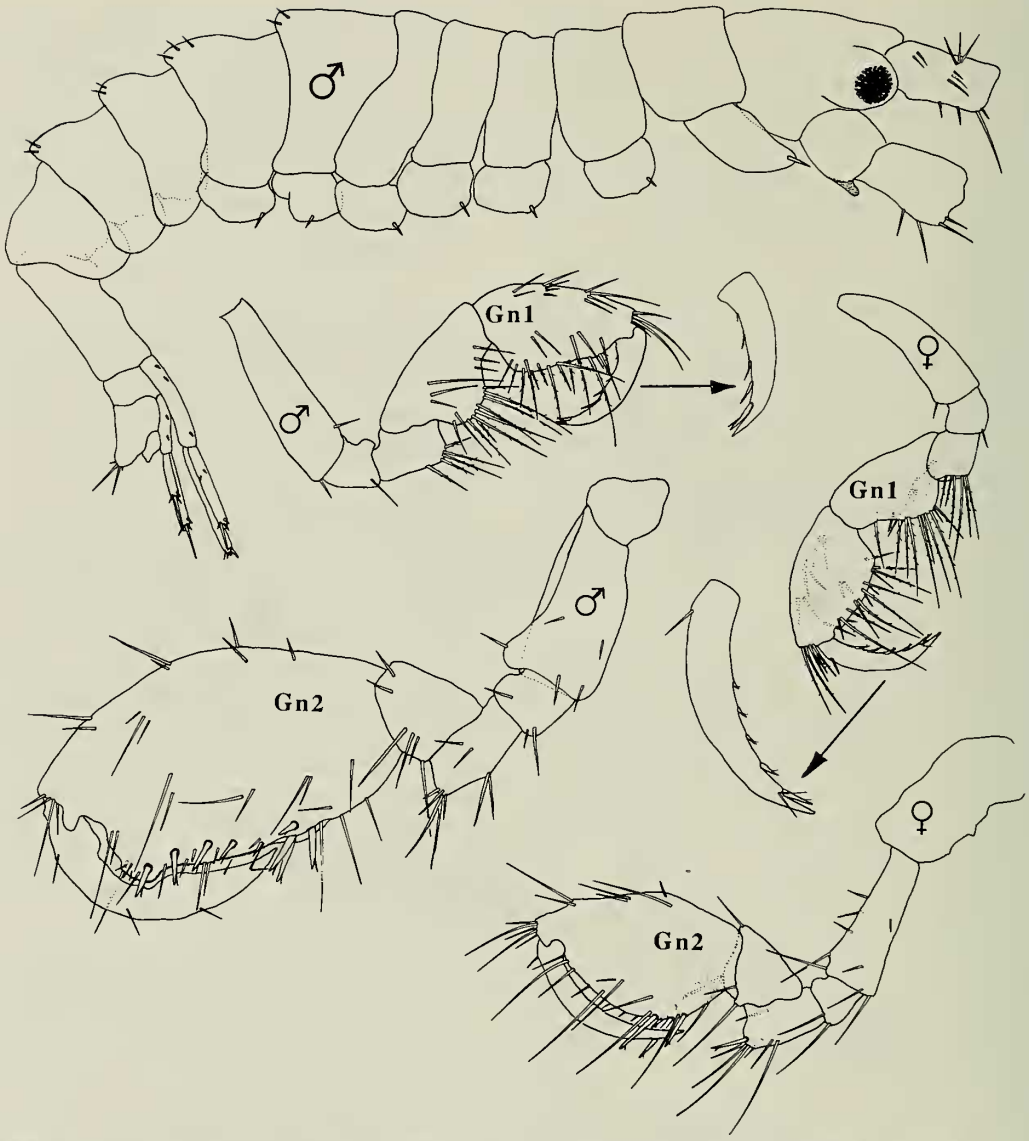

Fig. 6. *Podocerus lazowasemi,* male, 3.0 mm, YPM No. 9260: body, Gn1, Gn2. Female, 2.4 mm, YPM No. 9261: Gn1, Gn2.

facial and apical setae; incisor with 4 teeth; lacinia with 5 teeth; spine row of 3 short, broad spines; molar normal. Maxilla 1, inner plate vestigial; outer plate with 8 strong apical spines, 2 of them bifurcate; palp 2-articulate, terminal article with 4 strong apical spines and 3 apical setae. Maxilla 2, inner plate with 10 apical setae, inner margin lined with fine setae; outer plate with 9 apical setae. Maxilliped, inner plate clavate with apical and facial setae, distal inner corner with a large marginal spine; outer plate <50% length of palp, with 4 inner marginal spines and with submarginal and marginal setae; palp 4-articulate with submarginal and marginal setae. Lower lip, normal.

Gnathopod 1, coxal plate rhomboidal

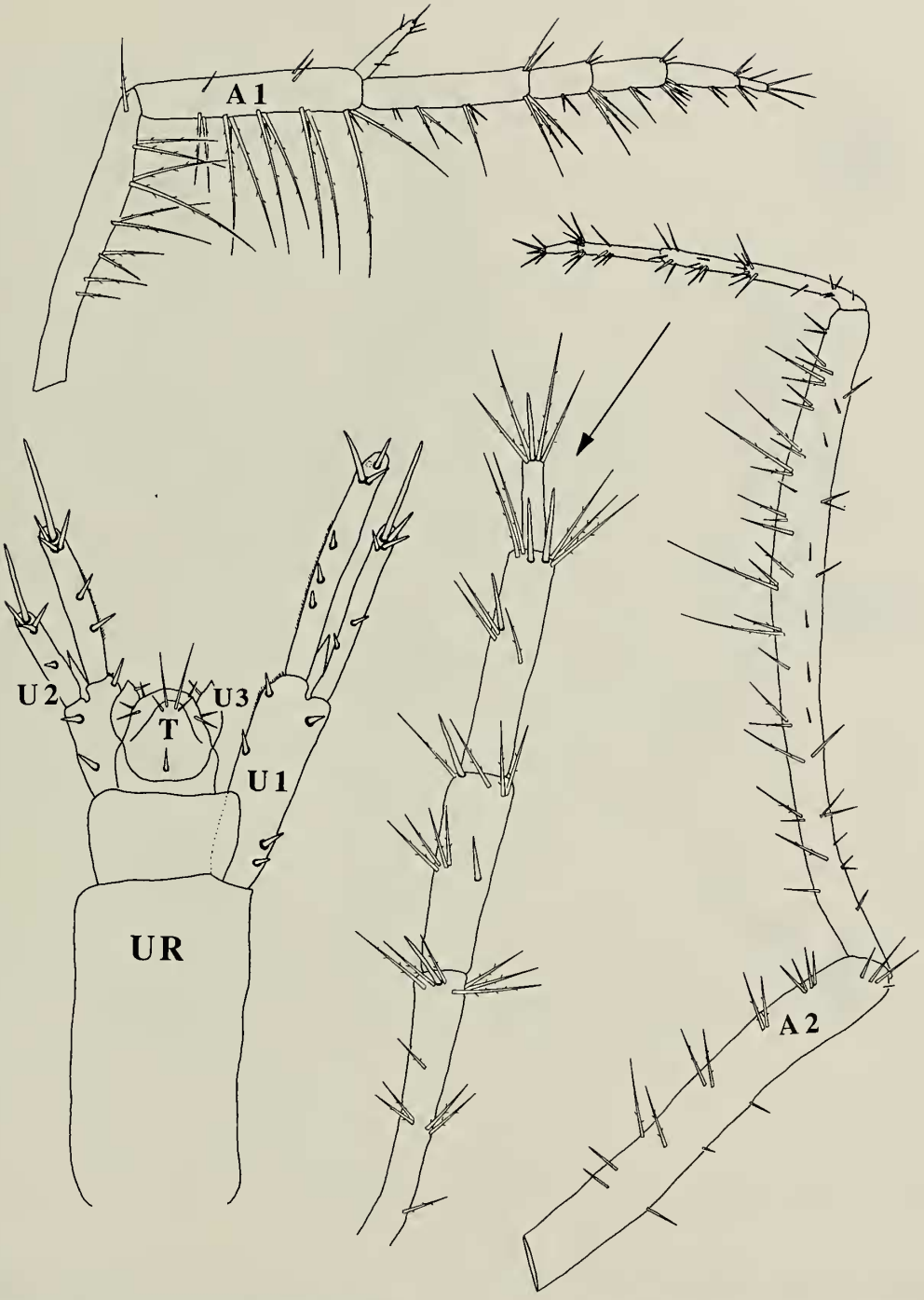

Fig. 7. *Podocerus lazowasemi,* male, 3.3 mm, YPM No. 9262: A1, A2. Male, 3.1 mm, YPM No. 9259: UR (with right U1, left U2, right and left U3, T).

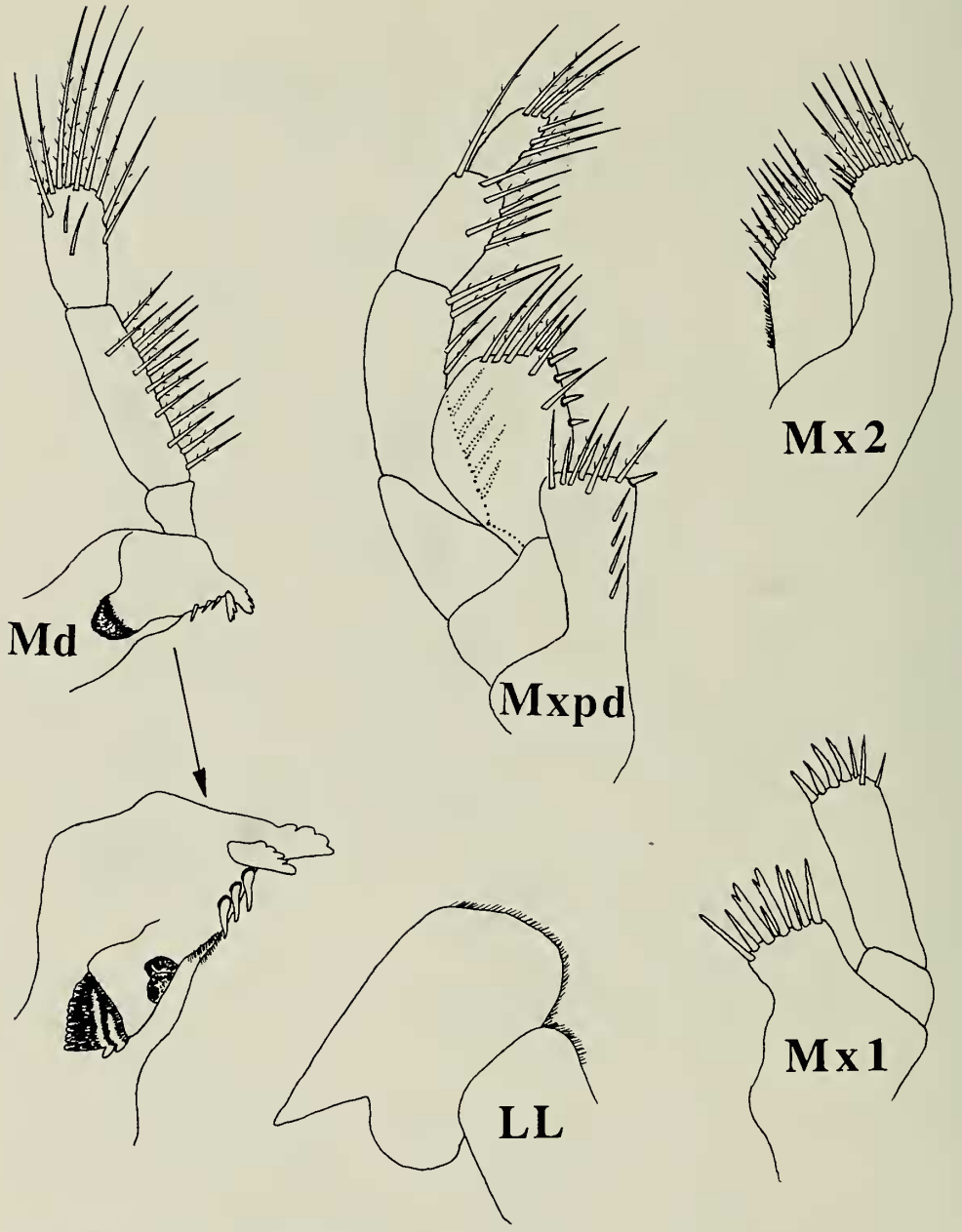

Fig. 8. *Podocerus lazowasemi,* male, 3.3 mm, YPM No. 8357.

with 1 large distoanterior spine; article 6, palm much longer than hind margin and with marginal setae, anterior margin with 4 setal groups; dactyl with 4 marginal setules and a subterminal bifurcate spine. Gnathopod 2 robust and much larger than gnathopod 1; basis triangulate, formed by a distoanterior lobed projection; article 6, palm setose with a pronounced distal rectangular process and 4 distinct submarginal bifurcate

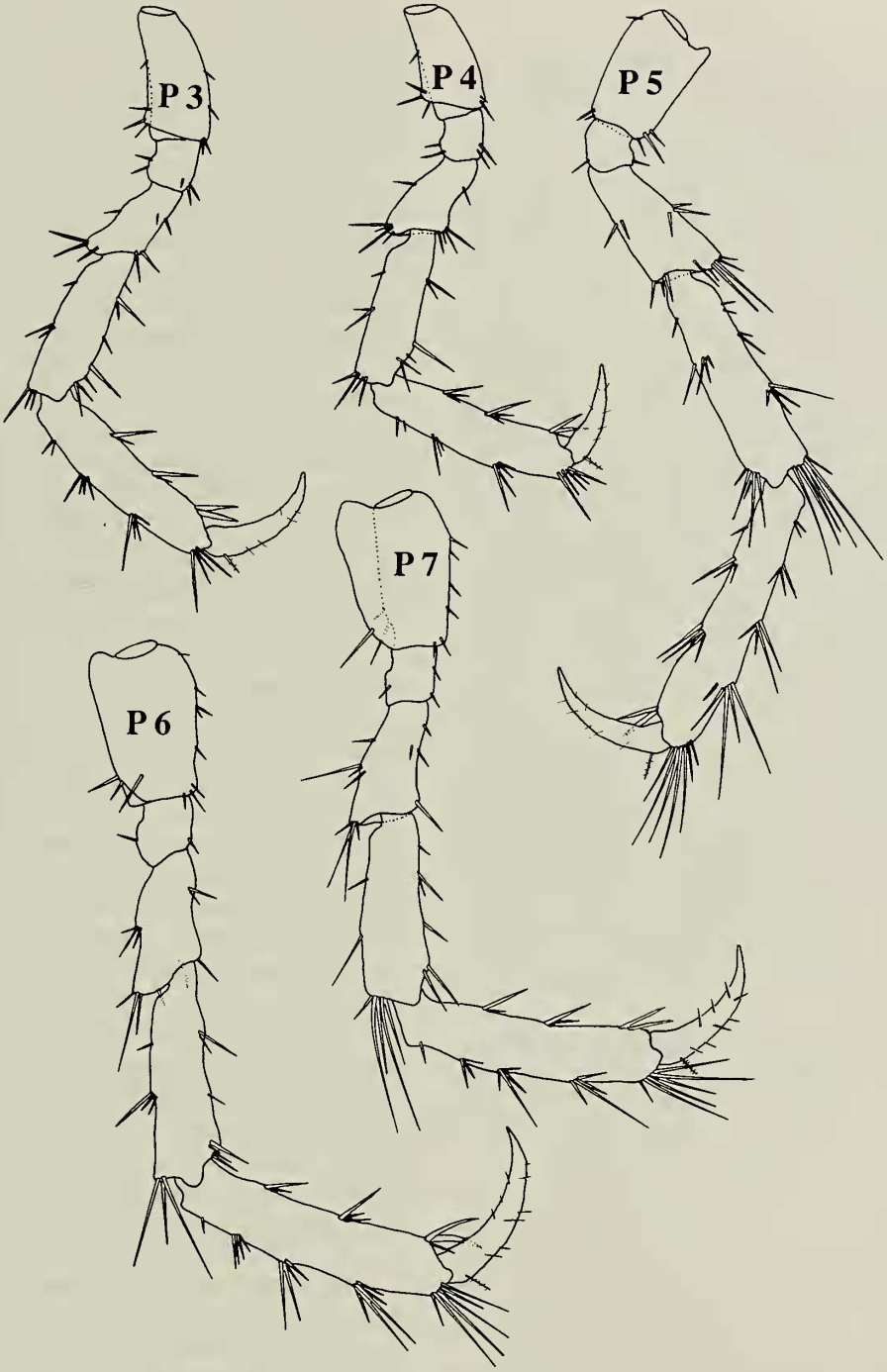

Fig. 9. *Podocerus lazowasemi,* male, 3.1 mm, YPM No. 9263.

spines, margin proximal to palm with 4 distinct bifurcate spines; dactyl with anterior marginal setae and a concavity fitting the rectangular process of article 6. Bases of pereopods 3–7 with posterior plate-like extensions becoming progressively more pronounced posteriorly, anterior and posterior margins of all articles variably spinose and setose. Dactyls each with a proximoanterior plumose seta.

Uropods 1 and 2 elongate, biramous; peduncles with a large interramal spine; rami with apical spines; peduncles and rami with marginal spines. Uropod 3 leaf-like with 1 marginal seta. Telson with 4 marginal and 2 submarginal posterior setae, 1 distinct anterior facial spine, and 4 setae; dorsally produced process with 2 long and 2 short setae.

Female: All features same as those for male except as noted. Gnathopod 2 resembling male, but less robust; basis lacking anterior lobed projection; palm lacking process and less spinose.

Remarks.—The marked differences in gnathopod 2 make *P. lazowasemi* sexually dimorphic. The dorsal carinations appear to become more pronounced as individual size increases. Although *P. lazowasemi* is typically non-pigmented, two specimens (YPM 9268 (juvenile) and 8371 (female)) possess pigment similar to females of *P. tachyrheo.*

Morphologically, *P. lazowasemi* most closely resembles *Podocerus fulanus* Barnard, 1962. Based on comparisons of specimens of both species, the most significant differences between *P. lazowasemi* and *P. fulanus* are: coxal plate ornamentation, *P. lazowasemi* with one distinct spine on each plate and *P. fulanus* with no spines or with one or more setae; number of flagellar articles on antenna 1, *P. lazowasemi* with five and *P. fulanus* with six; spination on posterior margin of article 6 of gnathopod 2, *P. lazowasemi* with four palmar bifurcate spines and four submarginal bifurcate spines proximal to the palm and *P. fulanus* with simple spines on the palm and no spines proximal to the palm; spination of inner ramus of uropod 1, *P. lazowasemi* with three marginal spines and *P. fulanus* with eight–nine marginal spines. Barnard (1979) also describes the pereon and pleon segments of *P. fulanus* as having lateral cusps, and "ordinary" specimens (3–4 mm) as having two telsonic spines, the number variable depending upon the size of an individual. Lateral cusps are not present in *P. lazowasemi* and the number of telsonic spines does not seem to be size-related.

Podocerus fulanus is a Pacific species widely distributed in the open sea of Mexico and is limited to warm, ponded embayments of southern California (Barnard 1979). The recently described *Podocerus kleidus* Thomas & Barnard, 1992a from the Florida Keys is also morphologically similar to *P. lazowasemi* but still quite distinct. *Podocerus kleidus* lacks spines on the flagellum of antenna 2 and has an excavate coxa 1. *Podocerus fulanus* differs most significantly from *P. kleidus* in the lack of an excavate coxa 1 and has fewer medial spines on the outer rami of uropods 1 and 2 (Thomas & Barnard 1992a). With the differences between *P. lazowasemi, P. kleidus* and *P. fulanus* having been delineated, and as *P. lazowasemi* does not have an excavate coxa 1, *P. lazowasemi* is considered another endemic Bermuda amphipod.

Precise microhabitat preferences for *P. lazowasemi* are, unfortunately, not known, as most specimens are from general rock and algal washings. Some specimens were taken from collections of turtle and manatee grasses, *Thalassia testudinum* Konig & Sims and *Syringodium filiforme* Kütz, but it is not known if the amphipods were holding onto the grasses or onto epifauna, e.g., hydroids. *Podocerus lazowasemi* has been found from very shallow sublittoral waters to a depth of approximately 8 m.

Material examined.—Male holotype, YPM 9256, Long Bird Causeway (¼ from S end), Bermuda, M. F. Gable, 31 May 1987, 3.2 mm, washings from shallow, subtidal

rocks. Female allotype, YPM 9257, Long Bird Causeway (¼ from S end), Bermuda, M. F. Gable, 31 May 1987, 3.2 mm, ovigerous, washings from shallow, subtidal rocks. 2 paratypes, ovigerous female, juvenile, YPM 9258 (same data as YPM 9257), 3.3 mm (female), 1.5 mm (juvenile). 2 male paratypes, USNM 346847, S Ireland Island, Bermuda, M. L. Jones, 31 Aug 1981. 1 male paratype, YPM 9259, Long Bird Causeway (¼ from S end), Bermuda, A. J. Baldinger, 31 May 1987, 3.1 mm, washings from shallow, subtidal rocks. 1 male paratype, YPM 9260, Spanish Point, Bermuda, E. A. Lazo-Wasem, 17 Jun 1988, 3.0 mm. 1 female paratype, ovigerous, YPM 9261 (same data as YPM 9260), 2.4 mm. 2 paratypes, male, female, YPM 9262, Ferry Reach, St. George's, Bermuda, E. A. Lazo-Wasem, 29 May 1987, 3.3 mm (male) and 2.2 mm (female). 1 male paratype, YPM 9263, Whalebone Bay, St. George's, Bermuda, E. A. Lazo-Wasem, 31 May 1987, 3.3 mm. 3 paratypes, 1 male, 2 female (1 ovigerous), YPM 8371, Tobacco Bay, St. George's, Bermuda, M. F. Gable, 2 Jun 1985, 4.6 mm (male), 3.4 mm (ovigerous female), 2.3 mm (female). 1 male paratype, YPM 8359, Bailey's Bay, Bermuda, A. J. Baldinger, 22 May 1987, 3.4 mm, 25 ft, SCUBA, algae attached to sand. 1 female paratype, ovigerous, YPM 8360, Whalebone Bay, St. George's, Bermuda, E. A. Lazo-Wasem, 31 May 1987, within *Thalassia testudinum* Konig & Sims and *Syringodium filiforme* Kütz. 1 juvenile paratype, YPM 9268, Shelly Bay, off Promontory, Bermuda, M. F. Gable, 27 May 1987, 2.5 mm. 1 male paratype, YPM 8357, Bailey's Bay, Bermuda, A.J. Baldinger, 22 May 1987, 3.3 mm, 25 ft, SCUBA, washed from algae attached to coral heads. 1 male paratype, deposited by YPM in Bermuda Museum of Natural History, Bailey's Bay, Bermuda, E. A. Lazo-Wasem, 17 Jun 1988, from algal washings. 1 female paratype, ovigerous, deposited by YPM in Bermuda Museum of Natural History (same data as YPM 9259).

Conclusions

Both Barnard & Karaman (1991) and Thomas & Barnard (1992b) provide a useful generic diagnosis for *Podocerus* and a species list. Considerable confusion still remains, however, regarding the taxonomy of *Podocerus*. Several authors (Barnard 1962, Nath 1972, Laubitz 1983, Ledoyer 1986) review the taxonomic problems and strongly suggest the need for a complete revision of the genus. Podocerids tend to be very fragile; limbs are often missing or broken, and descriptions and illustrations are incomplete for many species. Morphologically, the known intraspecific variability of podocerids amplifies the confusion regarding the taxonomy of this genus (Nath 1972).

A practical approach to the *Podocerus* problem is to give specific names to each population separated by considerable geographical distances, rather than assuming local variation on the part of one and the same species (Ledoyer 1986). In addition, Ledoyer recommends that the armature of the pereon, the configuration of gnathopods 1–2, particularly the palm and dactyl, and the morphology of the uropods and telson should be taken as reliable criteria for the identification of species of *Podocerus*. Despite Ledoyer's suggestion that any new podocerid not seeming to fit an existing species should for now be described as a new species, the authors believe that these two podocerids from Bermuda are not just variations but are genuinely new species.

Acknowledgments

The authors thank E. A. Lazo-Wasem, Peabody Museum of Natural History, Yale University, for his assistance in the collection of specimens, helpful comments on illustrations, preparation of photostats, and generous help in dealing with museum collections. J. W. Martin, Natural History Museum of Los Angeles, was gracious in attempting to locate deposited specimens of *P. fulanus*. The authors appreciate the help

of the late J. L. Barnard in obtaining specimens of *P. fulanus* for comparative studies and will remember his many helpful suggestions during our first encounters with podocerid identification. The authors thank A. Patnode III, Eastern Connecticut State University, for French to English translations of resource literature. This project has been partly supported by a Connecticut State University Grant to the second author. Contribution No. 1376 from the Bermuda Biological Station for Research.

Literature Cited

Barnard, J. L. 1962. Benthic marine Amphipoda of southern California: families Aoridae, Photidae, Ischyroceridae, Corophiidae, Podoceridae.—Pacific Naturalist 3:1–72.

———. 1979. Littoral gammaridean Amphipoda from the Gulf of California and the Galapagos Islands.—Smithsonian Contributions to Zoology 161:1–149.

———, & G. S. Karaman. 1991. The families and genera of marine gammaridean Amphipoda (except marine gammaroids).—Records of the Australian Museum, Supplement 13:1–866.

Barnard, K. H. 1925. Contributions to the crustacean fauna of South Africa.—Annals of the South African Museum 20:319–380.

Gable, M. F., E. A. Lazo-Wasem, & A. J. Baldinger. 1988. A description of the pigmented and nonstygobiontic females of *Podobothrus bermudensis* Barnard and Clark, 1985 (Crustacea: Amphipoda: Dulichiidae).—Proceedings of the Biological Society of Washington 101:145–150.

Griffiths, C. L. 1975. The Amphipoda of southern Africa, Part 5. The Gammaridea and Caprellidea of the Cape Province west of Cape Agulhas.—Annals of the South African Museum 67: 91–181.

———. 1976. Guide to the benthic marine amphipods of southern Africa. South African Museum, Cape Town, 106 pp.

Johnson, S. E. 1986. Order Amphipoda. Pp. 372–381 *in* W. Sterrer, ed., Marine fauna and flora of Bermuda. John Wiley and Sons, New York, 742 pp.

Kunkel, B. W. 1910. The Amphipoda of Bermuda.—Transactions of the Connecticut Academy of Arts and Sciences 16:1–126.

Laubitz, D. R. 1983. A revision of the family Podoceridae (Amphipoda: Gammaridea).—Memoirs of the Australian Museum 18:77–86.

Ledoyer, M. 1986. Crustacés amphipodes gamariens, familles des Haustoriidae à Vitjazianidae.—Faune de Madagascar 59(2):599–1112.

Nath, P. R. 1972. A new species of *Podocerus* Leach (Amphipoda) with a redescription of *Podocerus brasiliensis* (Dana, 1853).—Crustaceana Supplement 3:299–307.

Thomas, J. D., & J. L. Barnard. 1992a. *Podocerus kleidus,* new species from the Florida Keys (Crustacea, Amphipoda, Dulichiidae).—Bulletin of Marine Science 51:309–314.

———, & ———. 1992b. *Podocerus chelonophilus,* a testudinous amphipod newly recorded from the western Atlantic Ocean.—Bulletin of Marine Science 50:108–116.

(AJB & MFG) Department of Biology, Eastern Connecticut State University, Willimantic, Connecticut 06226-2295, U.S.A.; (AJB Current Address) Department of Invertebrate Zoology and Geology, California Academy of Sciences, Golden Gate Park, San Francisco, California 94118-4599, U.S.A.